

Active Solid State Dosimetry

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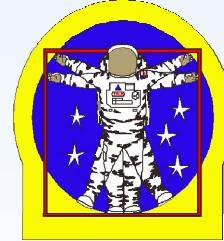
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Active Solid State Dosimetry

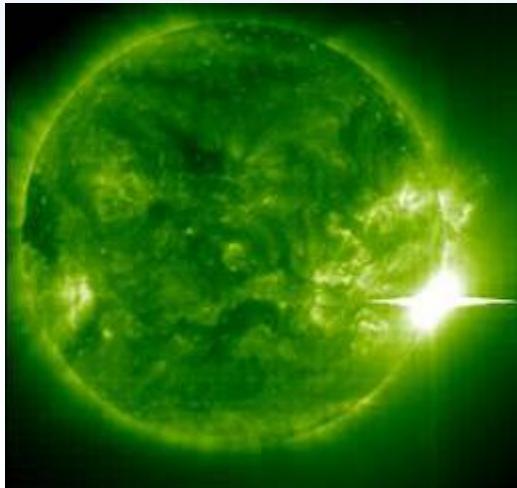
- The Radiation Threat
 - Space Radiation Environment
 - Threat to Astronauts
 - Dosage Issues
- Radiation Measurement Systems
 - Current Systems
 - Mission Needs
 - Technology Challenges
- Technology Development
 - NASA GRC Expertise
 - Relevant Technology Development
 - Current Status



Space Radiation

Space Radiation Environment

- GCR – Galactic Cosmic Radiation (GeV/amu ions)
- SPE – Solar Particle Event (GeV ions from sun)
- Trapped Radiation (GeV/amu ions & electrons)
- Secondary Neutrons (from surface & structures)
- Man-made Sources (RTG's, etc.)



*X-Ray Flare of
04 Nov 2003
from SOHO
(left)*

*Aurora
Australis
from STS-39
(right)*



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The Radiation Threat

Space radiation can cause damage to an astronaut's DNA.

Damage can be short term (acute) and/or long term (chronic):

- Acute effects typically include radiation burns and/or nausea ("radiation sickness")
- Chronic effects include cataracts, sterilization, brain damage, and/or an increased risk of cancer

"Strategic Program Plan for Space Radiation Health Research,"

NASA Office of Life and Microgravity Sciences and Applications (1998)

Space radiation can also damage silicon microelectronics by affecting the carrier density and increasing the leakage current, leading to equipment malfunction and failure.

Astronauts are Radiation Workers!

- Radiation exposure to personnel and equipment is a significant health and operational issue.

Dosage Issues

- 8-hour LEO EVA (Shuttle/ISS)
 - Nominal EVA Dosage: 0.1 mSv (10 mrem)
 - After geomagnetic storms: 10 mSv (1 rem)
 - Higher during SPE's
- 8-hour Lunar Surface EVA
 - As high as 1000 mSv (100 rem) during small SPE's
- Standard ALARA Practice (DOE-STD-1098-99) for compliance with 10 CFR 835 calls for active personal monitoring of dosages greater than 1 mSv (100 mrem) over 8 hrs
- Man-Systems Integration Standards (NASA-STD-3000) calls for the active monitoring of radiation dosage during an entire mission, and for EVA this includes either active or passive measurements for each crewmember.

Radiation Measurement Systems on ISS

EVCPDS: Extra-Vehicular Charged Particle Directional Spectrometer (active telemetry)

IVCPDS: Intra-Vehicular Charged Particle Directional Spectrometer (active telemetry)

TEPC: Tissue Equivalent Proportional Counter
(active telemetry)

RAM: Radiation Area Monitor
(TLD's) (passive)

CPD: Crew Passive Dosimeter
(TLD's) (passive)

Space Radiation Analysis Group
<http://srag-nt.jsc.nasa.gov/>



ISS from STS-114

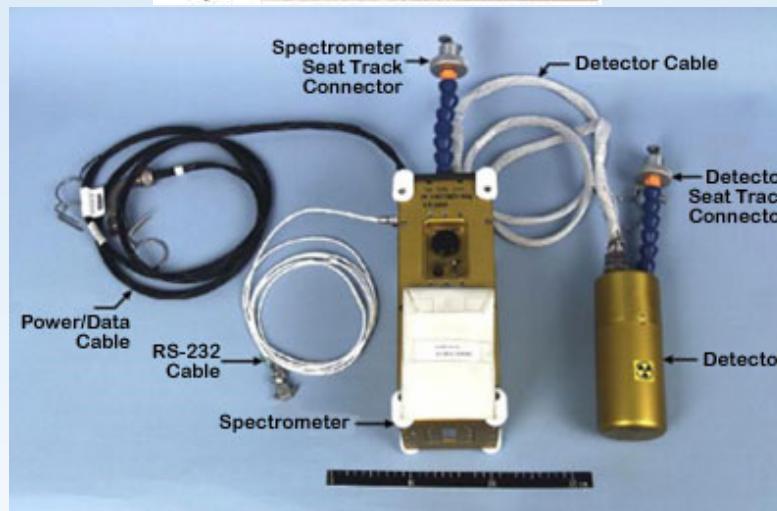
Radiation Measurement Systems on ISS

- RAM / CPD



*Pictures from the
Space Radiation Analysis Group
<http://srag-nt.jsc.nasa.gov/>*

- TEPC



- IVCPDS
& EVCPDS



Mission Need

- Current monitoring of radiation conditions during EVA is limited to post-mission, accumulative information provided by dosimeter badges.
- Active personal dosimeter for Low Earth Orbit (LEO) EVA use is specifically recommended by NASA JSC's Radiation Dosimetry Working Group (2003).
- National Council on Radiation Protection and Measurements (2002) recommends personal radiation monitoring for real-time dose rate & integrated dose in LEO.
- Compared to the current LEO missions, the expeditions to the Moon will place crews at a significantly increased risk of hazardous radiation exposure.

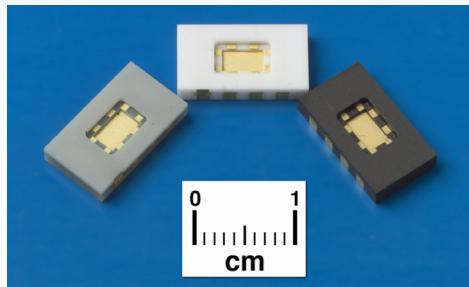
Technology Development Challenges

- Astronauts need to be aware of potentially hazardous conditions in their immediate area on EVA before a health and hardware risk arises.
- Real-time feedback of personal dosimeter information regarding astronaut conditions is currently not available.
- Real-time dosimeters based on silicon electronics could provide real-time information but silicon lacks the desired sensitivity and is itself affected by radiation, decreasing the effectiveness of this technology.
- Improvements in the basic dosimeter design would provide a valuable tool to improve astronaut safety and provide better awareness of the external situation.

NASA GRC Instrumentation & Controls Division

Conducts in-house basic and applied research of advanced instrumentation and controls technologies for aerospace propulsion and power applications:

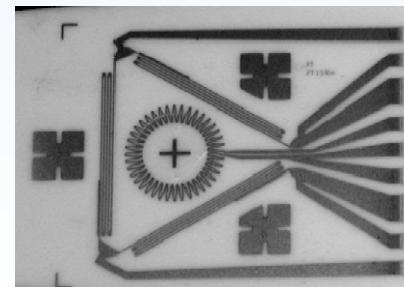
- Harsh environment sensors
- High temperature high power electronics
- MEMS & nanotechnology based systems
- High data rate optical instrumentation
- Active and intelligent controls
- Health monitoring and management



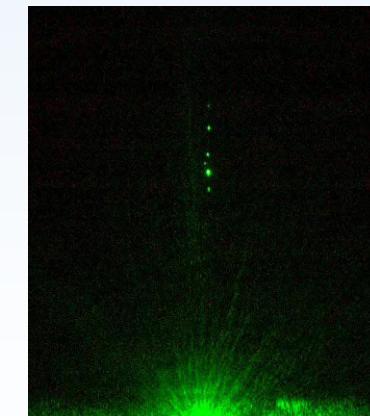
Harsh Environment Packaging
(L.Y.Chen)

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Thin Film Physical Sensors
(G.C.Fralick & J.D.Wrbanek)

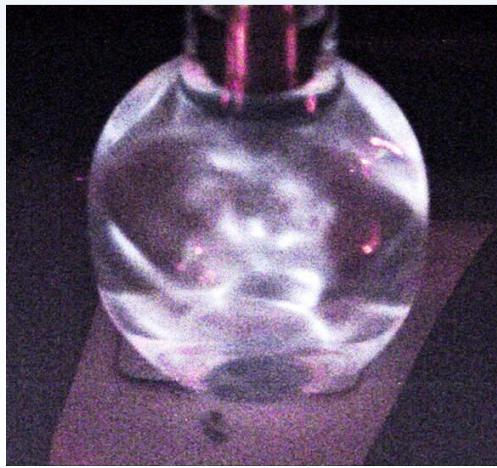


Optical Micromanipulation
(S.Y.Wrbanek)



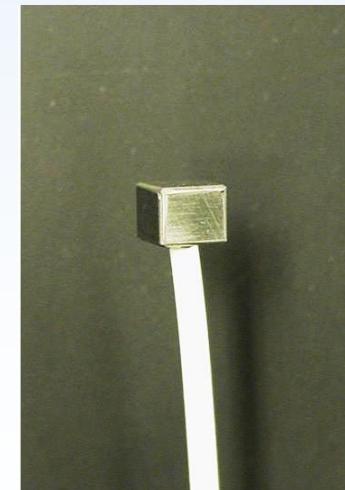
Radiation Detector Development

- Claims and theories are being examined that predict a net gain of power resulting from atomic interactions at the high temperatures and pressures present in sonoluminescence.
- Sonoluminescence-based power generation has been only recently reported in the main-stream academic press.
- NASA GRC is attempting to verify these claims using thin film coated scintillation detectors fabricated at NASA GRC.



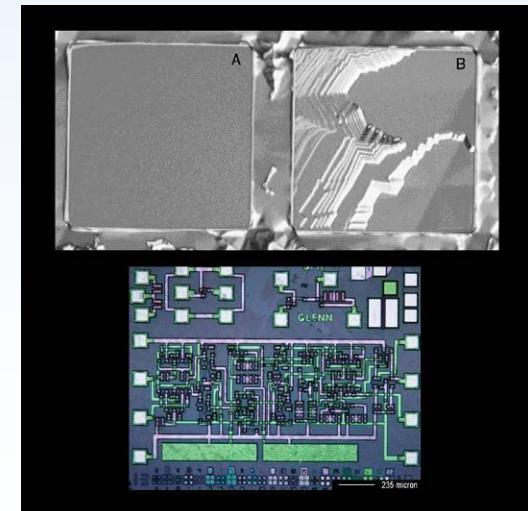
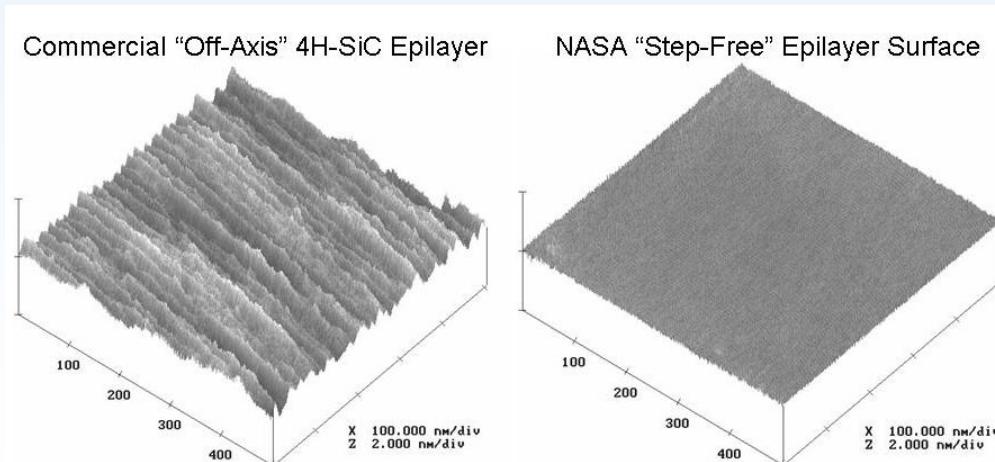
**MBSL in Water
(left)**

**Fiber Optic
Scintillation Detector
(right)**



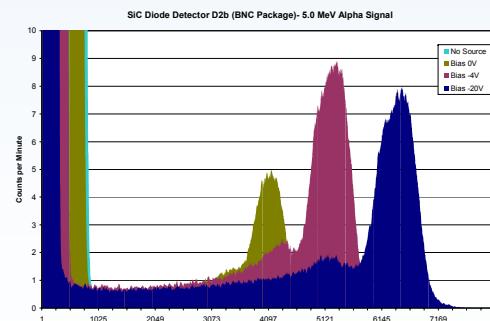
SiC Semiconductor Technology Development

- NASA GRC has been leading the world in the development of SiC semiconductor technology.
- NASA GRC produces SiC semiconductor surfaces of much higher quality than commercially available.
- These surfaces have demonstrated advantages over standard materials for sensor applications.



Solid-State Radiation Detector Development

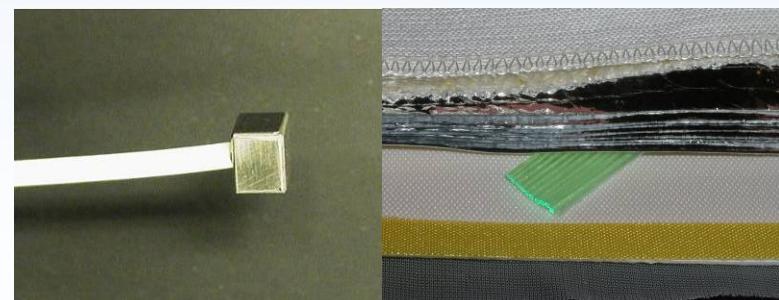
- Developing miniature solid-state detectors for detection & identification of Alpha, Gamma, Neutron radiation
- Leveraging experience in Wide-Band Gap SiC technology and Fiber Optic Devices to produce lower noise, smaller, more thermally stable detectors
- Applications to Active Dosimetry and Radiation Source Identification
- Scalable to Application Need
- Characterizing SiC and Fiber Optic devices in FY06



Testing SiC Radiation Detectors

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**Fiber Optic Radiation
Detector Concepts**

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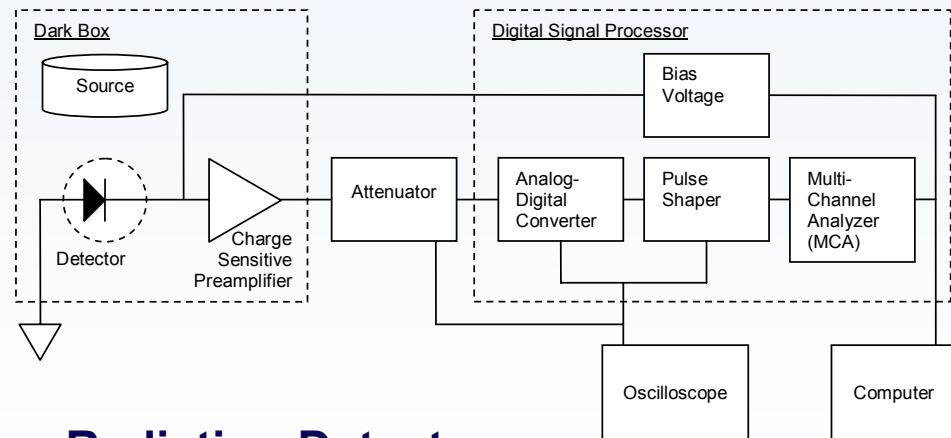
Detector Trade-Offs

Issue	Semiconductor Detectors	Scintillation Detectors
High Voltage	Required at each detector for biasing	Pulse counter can be some distance from detector
Detector Area	Miniature to postage stamp size	Optical fiber to large area
Energy Resolution	Excellent – Guided by Fano Statistics	Pure Poisson Statistics – Not as refined but well understood

- Advantages and Disadvantages depending on the Application

Current Status

- Test Stand using Alpha/Gamma sources completed and is being upgraded
- Improving packaging for both Fiber Optic and SiC detectors to improve signal to noise ratio
- Development effort under Advanced Extra Vehicular Systems and Low Emissions Alternative Power projects end after FY06



**Radiation Detector
Development Lab**

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